"SURVEILLANCE OF PERIPHERAL ARTERIAL BYPASS GRAFT"

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M.Ch., (VASCULAR SURGERY)

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DECLARATION

I solemnly declare that this dissertation **"SURVEILLANCE OF PERIPHERAL ARTERIAL BYPASS GRAFT"** was prepared by me in the Department of Vascular Surgery, Government General Hospital, Madras Medical College, Chennai under the guidance and supervision of **Prof. T.VIDYASAGARAN, MS, DNB, M.Ch**., Professor & Head of the Department, Department of Vascular Surgery, Government General Hospital, Madras Medical College, Chennai. This dissertation is submitted to the Tamil Nadu Dr.MGR Medical University, Chennai in partial fulfillment of the University requirements for the award of degree of M.Ch., Vascular Surgery.

Place : Chennai
Date :

CERTIFICATE

This is to certify that this dissertation entitled **"SURVEILLANCE OF PERIPHERAL ARTERIAL BYPASS GRAFT"** is a bonafide record of the research work done by Dr. K. Jayachander, for the award of M.Ch., Vascular Surgery, under the supervision of **Prof. T. VIDYASAGARAN MS, DNB, MCH,** Professor & Head, Department of Vascular Surgery, Government General Hospital, Madras Medical College, Chennai. I also certify that this dissertation is the result of the independent work done by the candidate.

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Last but not the least, I thank the patients who have willingly participated in this study and despite their ailments, placed their faith in us.

CONTENTS

INTRODUCTION

The term graft surveillance refers to periodic evaluation of the grafts by means of tests that may involve special instrumentation, by which an abnormal result, suggest, the presence of pathology .By graft surveillance, we can pick up failing grafts and with corrective measures, patency rates can be improved.

The steady decline with time in the patency of vascular grafts mandates a protocol of postoperative surveillance to identify grafts at risk of thrombosis since bypass graft occlusion is associated with significantly morbidity and limb loss . The correction of lesions before graft thrombosis can have a significant impact on long term patency. It is particularly important for vein grafts because most will not maintain patency after thrombectomy.

Careful postoperative evaluation of patients especially with infrainguinal grafts over the past decade has clearly demonstrated that factors other than the skill of the surgeon and the completion of satisfactory operative procedure will affect the long term patency of vascular conduits.These factors vary depending on the interval in the follow-up period.Factors adversely affecting 30 day patency are primarily technical in nature and are related to surgical technique.Such factors are best prevented and can often be identified by intraoperative evaluation.In the time period between 1 month and 24 months fibrointimal hyperplasia in a variety of forms is the primary cause of graft failure. Beyond 24 months the disease progression in both the inflow and outflow vessels and the conduit degenerative changes results in graft failure. The importance of graft surveillance has inspired to conduct this study in order to clarify the natural history of graft failure.

AIM

- To detect the hemodynamically failing and failed grafts regardless of symptoms during the follow up.
- To analyse the outcome of revision procedures.
- To study the influence of risk factor on graft survival.

MATERIALS AND METHODS

Prospective study

Study period: May 2007 to April 2009

Patient selection

Randomly 98 grafts in 92 patients were enrolled in this study who underwent bypass operation for critical lower limb ischemia and severe disabling claudication.

Inclusion criteria

All patients who underwent peripheral arterial bypass for critical limb ischemia including major aortic surgeries

Fontaine classification of Chronic limb ischemia based on symptoms

I. Asymptomatic .(No hemodynamically significant occlusion)

II. Claudication

III. Ischemic rest pain

IV. Ischemic ulcer / Necrosis.

Exclusion criteria

- Acute limb ischemia.
- Upper limb ischemia

- Visceral and cerebral ischemia.

- Immediately thrombosed grafts (Within 24 hours)

ETIOLOGICAL FACTORS

Arterial disease of the lower limbs includes conditions such as inflammatory arteritis,vasospastic disorders and medial calcification. However, by far the commonest cause of peripheral arterial disease is Atherosclerosis consisting of slow accumulation of lipids and fibrosis in the arterial intima.

All the patients were categorized according to the etiological factors as

- **Atherosclerotic obliterans**
- **Thromboangitis obliterans** :Fullfilling Shionoya's criteria
  1. Less than 50 years age of onset
  2. Smoking
  3. Infrapopliteal lesion
  4. Upper limb lesion
  5. Phlebitis migrans and
  6. Absence of ASO risk factors
- **Arteritis** on the basis of raised CRP and
- **Hypercoagulable** state ,based on positive test for cryoglobulin in this study.

Cryoglobulins are immunoglobulin that precipitate reversibly at low temperature.

MANAGEMENT OF CHRONIIC CRITICAL LEG ISCHEMIA

1. **Endovascular intervention**: The optimum lesion for PTA(Percutaneous transluminal angioplasty) are short stenosis or occlusions of the iliac and the proximal SFA with good run off.

2. **Surgery** : For long occlusion and infrainguinal lesion endovascular treatment is more complex and if intervention is required then bypass surgery gives better results

3. **Non-interventional management**: In about 10% of patients ,it will be technically impossible to revascularise th limb.Several pharmacological agents have been tried and the most promising are prostanoids, particularly prostacyclin.Iloprost ,a stable prostacyclin analogue , has reduced the amputation and death.In some patients the limb survives ,but pain remains a problem.If simple analgesia is inadequate then Lumbar sympathectomy either chemical or surgical may be helpful

In this study only patients who under went bypass surgery were enrolled.

INDICATION FOR BYPASS

- **Severe disabling claudication**: Patient develop severe claudication symptoms after a few steps and walking is impossible even in the absence of gangrene, ulceration or rest pain.

- **Critical limb ischemia** : The most European Consensus Document defines CLI as persistent, recurring ischemic pain requiring opiate analgesia for at leats 2 weeks and ankle systolic pressure lower than 50

mmHg and or toe systolic pressure lower than 30 mmHg; or ulceration or gangrene of the foot or toes and ankle systolic pressure lower than 50 mmHg (or absent pedal pulse in diabetics).

Critical limb ischemia is often fatal if untreated, but even after arterial reconstruction or amputation,40-75% of patients will die within 5 years of presentation mainly due to cardiac problems.

LEVEL OF ANASTOMOSIS

All were categorized according to the level of occlusion and analysed for the type of revascularization as follows

- Aorto iliac and Aortofemoral
- Iliofemoral
- Femoro – Femoral crossover
- Femoro –Popliteal
- Distal bypass

While performing distal bypasses we optimize the mechanical factors in distal anastomosis in order to reduce the compliance mismatch and to reduce shear stress by creating anastomotic vein cuff or vein patch (Millers cuff,Lintons patch,Taylors patch and St Marys Boot) in case of prosthetic graft placement .Also we use topical papavarine and intraoperative Dextran infusion 15 ml/hour, continued in postoperative period for 48 hours if cardiac function is good

NATURE OF GRAFTS STUDIED.

All patients were separated according to the type of conduit used for bypass, from the data during hospital stay and for few patients from the discharge summary during the follow up into as

- Autogenous vein and
- Expanded PTFE.

GAUGING THE CLINICAL CHANGE AFTER BYPASS

Following revascularization a sustained rise of >0.15 of ABI was taken to indicate a Successfulbypass (Normal ABI is > 0.97) and the clinical change is gauged after revascularization as follows.

Gauging clinical change after revascularizations + 3	Markedly improved No ischemic symptoms Foot lesions healed ABI normalized – increased to more than 0.90
+2	Moderately improved No foot lesion but still symptomatic with exercise ABI not normalized but increased by >0.10
+1	Minimally improved Greater than 0.10 increase in ABI but no categorical improvement
No change	No categorical shift and less than 0.10 changes inABI
- 1	Mildly worse ABI decreased more than 0.10
-2	Moderately worse One category worse or unexpected minor amputation
-3	Markedly worse More than one category worse or unexpected major amputation

Limb salvage is defined as freedom from major amputation.

Minor amputation were defined as those result in a foot that could still be used for ambulation.

FOLLOW UP PERIOD

The initial evaluation of the graft starts prior to discharge or within one month after implantation,followed by on 3 months,6 months ,every 6 months for 2 years if above three evaluation are normal .After 2 years annual evaluation for life.

All the patients were recommended aspirin, or clopidogrel and, statin in ASO groups, postoperatively to decrease graft occlusion as well as for its cardio protective effects and in high risk group, long term anticoagulation (Tab .Acitrom) was advised.

METHODS OF SCREENING

At each visit grafts are screened by

- Clinical examination : Pulse palpation and auscultation for bruit
- ABI. Measurement using hand held continous wave Doppler

ABI is calculated by measuring highest systolic ankle pressure divided by the brachial systolic pressure .Brachial pressure is taken as standardization because it corresponds well with aortic and femoral pressure. Diastolic pressure does not fall until the stenosis is quite severe and hence systolic pressure is sensitive.

- Duplex scanning – Combination of B-Mode real-time anatomic imaging and Doppler spectral wave analysis with measurement of flow and velocity.

- Angiogram to delineate the lesion and to planning the revision procedure

Graft lesions were identified by recurrence of ischemia ,change in findings at clinical examination or with routine duplex scanning. Following the clinical examination and objective evidence of occlusion by duplex scan ,symptomatic patients were subjected for Angiogram and revision procedures and the outcome were assessed in terms of primary patency,assisted primary patency ,secondary patency ,limb salvage rate and patient survival rate.

GRAFT PATENCY

Primary patency : Patency is uninterrupted ie No interval procedure

Assisted primary patency: Primary patency is preserved after intervention of failing graft ie intervening on a patent graft such as angioplasty of stenosed but patent graft.

*Secondary patency :*Patency is restored after occlusion by any of the following procedures

- Thrombectomy using fogarty and adherent clot catheter

- Thrombolysis using systemic or regional injection streptokinase.(Contraindicated in early postoperative period (14 days), however intra graft injection to clear residual thrombus in distal arterial tree can be used) .Streptokinase therapy is monitored by serum fibrinogen and the therapy discontinued if fibrinogen level falls below 100 mg.

- Transluminal angioplasty for focal stenosis less than 1.5 cm (Our experience is limited due to lack of infrastructure)

- Patch plasty: Short focal stenosis (<4cm)

- Interposistion graft :Long stenosis >4cm

- Jump graft : long segment stenosis that approached the anastomosis

- Transposition graft :connecting the bypass to different vessel target

- Balloon angioplasty : focal lesion <1.5cm with segments of normal caliber vein proximal and distal.

- New graft: For diffuse intimal hyperplasia with narrowed caliber

DUPLEX SCANNING

The Duplex scan is highly sensitive and specific for identifying lesion that threaten the graft patency. Duplex scan identifies failing graft which is defined as hemodynamic disturbances without thrombosis. Color flow image rapidly identifies the region with high velocity or disturbed flow.

The criteria for graft lesion by Duplex scan depends on the velocity ratio should be recorded at site were velocities are abnormally elevated

Many defects detected during early postoperative period is due to residual defect caused by technical imperfection or residual disease . The residual defect have a velocity spectra of a moderate stenosis(30-60% diameter reduction) and thus are not associated with impairment of blood flow or perfusion pressure .It does appear that such residual defect in an arterial reconstruction increase the likelihood of clinical feature ,usually as a result of progressive myointima hyperplasia.

Important issues regarding graft surveillance include when the duplex surveillance begin, how long it should be continued and at what frequency to be performed. The first duplex scan should be performed at operation theatre if feasible, if not prior to discharge from hospital.The predischarge duplex examination permits identification of bypass which are prone to progress ,which if it occurs and is corrected in timely fashion dramatically reduce the incidence of thrombosis within first year after surgery.Graft sueveillance should be indefinite with majority of patients requiring an annual evaluation after first year

It helps to screen the whole graft where the following sites can be sampled

1. Proximal anastomosis
2. Proximal graft
3. Mid graft
4. Distal graft and
5. Distal anastomosis

Duplex criteria for normal flow in graft is PSV less than 125cm/sec & velocity ratio of 1:1.4

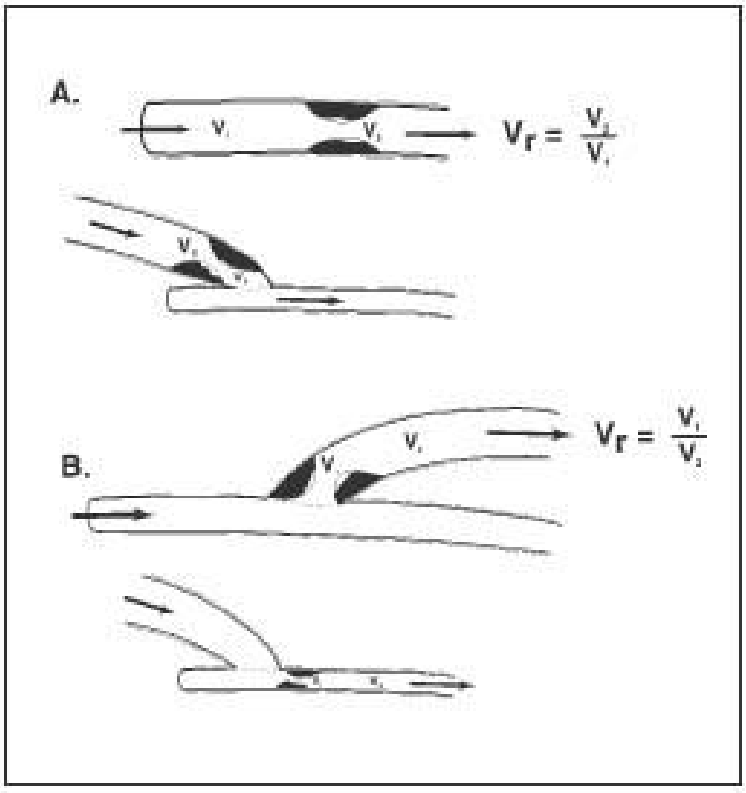
When flow disturbance is identified by duplex scan it is graded for severity by measurement of

- Peak systolic Velocity,
- Graft Flow Velocity
- Velocity ratio : $\frac{\text{Highest PSV with stenosis (V2)}}{\text{Normal proximal PSV(V1)}}$
- And when coupled with ABI can be used to categorise lesions as low risk ,intermediate risk, or high risk for graft thrombosis as follows .

THROMBOTIC RISK CATEGORY

Risk level	High velocity criteria	And	Low velocity criteria	And	ABI reduction
Highest	PSV >300 or Vr >3.5 or EDV >100	And	GFV <45	Or	>0.15
High	PSV >300 or Vr >3.5	And	GFV >45	And	<0.15
Intermediate	PSV 180-300 or Vr >2	And	GFV>45	And	<0.15
Low	PSV <180	And	GFv>45	And	>0.15

CALCULATING VELOCITY RATIO: V2/ V1



The diameter of the vein graft recorded, as large diameter (normal 3-6mm) will tend to have lower velocities. A graft that has consistently been a low flow graft is less worrisome than one that shows a serial change and develops a low flow velocity. A graft that has consistently low flow velocities may simply have

- .Large graft diameter
- .Low cardiac output or both.

When a graft develops a low flow state, attention should be directed to possible causes

- Loss of inflow
- Outflow impediment
- Critical graft stenosis creating a impediment of flow.

The shape of Doppler waveform is also important. Early in the postoperative period ,grafts have a continous antegrade flow during the cardiac cycle. This is thought to be secondary to the chronic vasodilatation caused by the baseline peripheral arterial lesions that have bypassed. As vascular tone is is regained over time the waveform becomes triphasic .Conversion from a triphasic to a monophasic waveform with decreased PSV is suggestive of a remote occlusive lesion. A preocclusive staccato signal portends a poor prognosis and is indicative of high grade stenosis in the distal graft.

The most common lesion that appears or progress after one month of surgery is by intimal hyperplasia that forms at a valve site, at anastomosis, venovenostomy site or within the graft body. Intimal hyperplasia; universal response of vessel to injury,describes a chronic structural change in denuded arteries,arterialized vein and prosthetic grafts.

Lesion appears during late postoperative period (> 2 years) often are disease progression of native arteries and occur with vein graft proper (ASO) or in the inflow or outflow arteries **.**

EXPECTED RANGE OF NORMAL VELOCITIES IN AORTA AND LOWER LIMB ARTERIES

Vessel	***PSV***	***EDV***
Aorta	60-110 cm/sec	
Iliac	119.3 +/- 21.7	16.4 +/- 7.5 cm/sec
CFA	114.1+/- 24.9	14.5 +/- 8.3
SFA prox	90.8 +/- 13.6	14.5+/-7.2
SFA mid	93.6 +/-14.1	14.6+/-6.7
SFA dis	68.8+/-13.5	9.8+/-6.0

The duplex finding in stenotic areas as follows

Stenosis: Flow reversal disappears

Reduce peripheral resistance due to relative ischemia

Damping pressure wave

Proximal to stenosis: High forward flow

Stenosis manifest as spectral broadening

Monophasic flow means flow always forward due to stenosis and low peripheral resistance(capiilaries open which is normal only after exercise and not in stenosis / obstruction)

Dampened flow: Distal to severe arterial obstruction due to slowed systolic acceleration & increased diastolic flow.

End diastolic velocity : Highest end diastolic velocity .It will be normal till 50% DR (diameter reduction).It will be elevated in 50-70 % DR to >100cm/s

STENOSIS RANGE AND EXPECTED VELOCITY CHANGES

% stenosis	***Peak velocity***	***Vr***	***waveform***
Normal	<150	<1.5:1	Triphasic
30-49 %	150-200	1.5:1-2:1	Triphasic spectral broadening
50-75 %	200-400	2:1-4:1	Monophasic spectral broadening
>75%	>400	>4:1	Monophasic spectral broadening
Occlusion	No flow		No signal

Grafts with low risk and intermediate risk are followed for progression .Intervention of the failing graft is recommended when PSV is >300 cm/sec and PSV ratio is more than 3.4. and for uniform low flow graft suggesting either inflow or outflow disease outside the graft .Angiogram was taken in all patients planned to revise in order to delineate the lesion and to plan the treatment .

Idu etal reported all infrainguinal vein grafts with 70% diameter reduction eventually occluded, compared to 10% of grafts, with similar lesion which were revised.

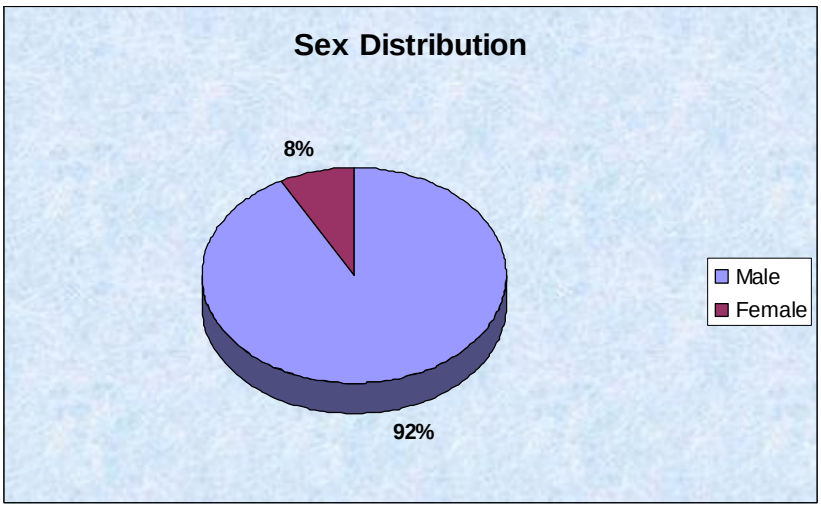
STATISTICAL ANALYSIS

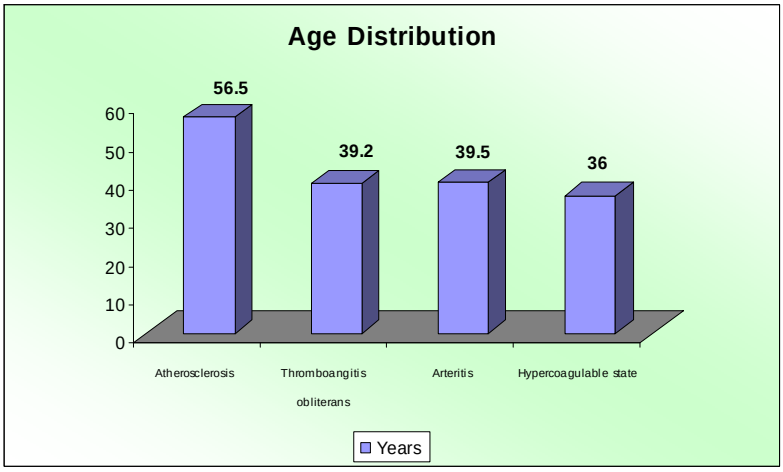
This study was statistically analysed by the Chi-square test to compare the

- Rate of graft lesion to that of etiology
- Rate of graft abnormality with the level of bypass
- Risk factors to that of graft patency
- Role of anticoagulation in graft patency
- Relationship of Etiology to that of outcome
- Influence of risk factors to the outcome
- Relationship of the graft nature to the patency
- Relationship of the type of surgery to the outcome

OBSERVATION & RESULTS

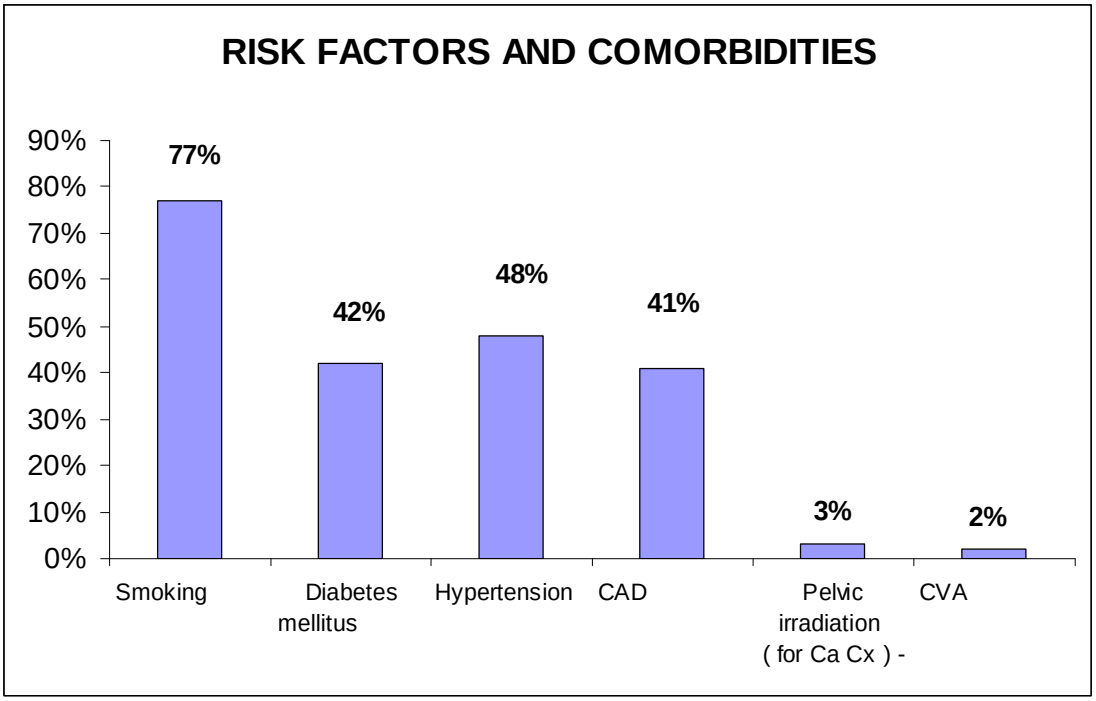
From May 2007 to April 2009 review of a prospectively collected data was performed of 100 patients who underwent bypass for lower limb ischemia due to various etiology was randomly selected and enrolled in this Study. Majority of them had critical limb ischemia as the indication of surgery. Two patients were excluded from the study due to poor follow up compliance and finally there were 92 patients in the study, 85 were males (92%) and seven females (8%).



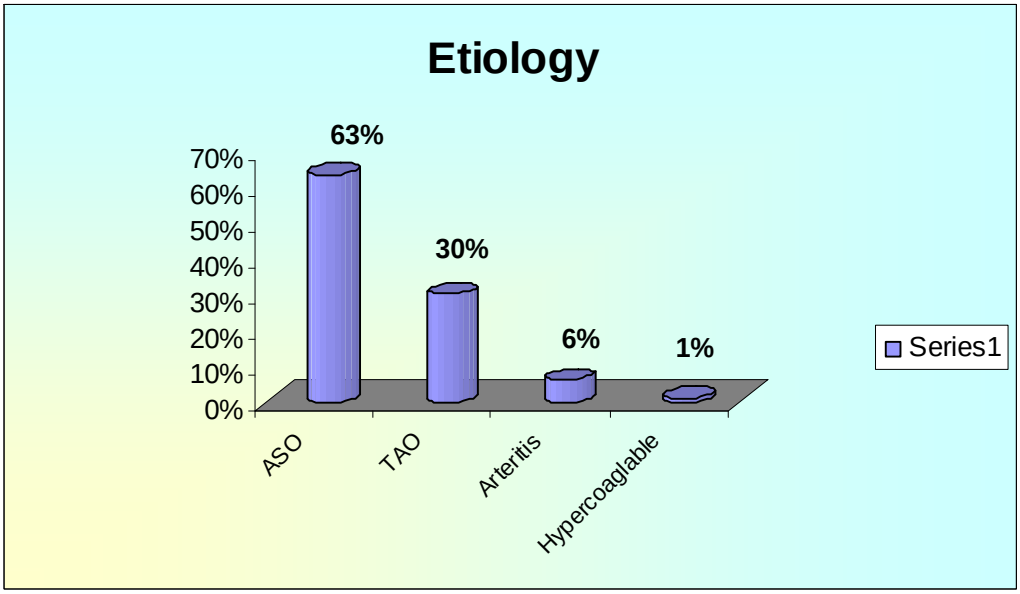


A total of 92 patients who underwent peripheral arterial bypass procedures whose data were collected. A total of 98 bypass grafts were enrolled for the study including the sequential bypasses(n=6).

The major risk factors were of smoking in 77%, diabetes mellitus, hypertension and coronary artery disease association in more than 40% of patients. Two female patients had history of carcinoma cervix with pelvic irradiation which accelerates the atherosclerosis



Regarding the etiology majority of the patients were having atherosclerotic risk and with mean age of 56.5years. Thromboangitis obliterans fulfilling Shionoya's criteria stood second in the study and only one had evidence of hypercoagulability cryoglobulin positive.



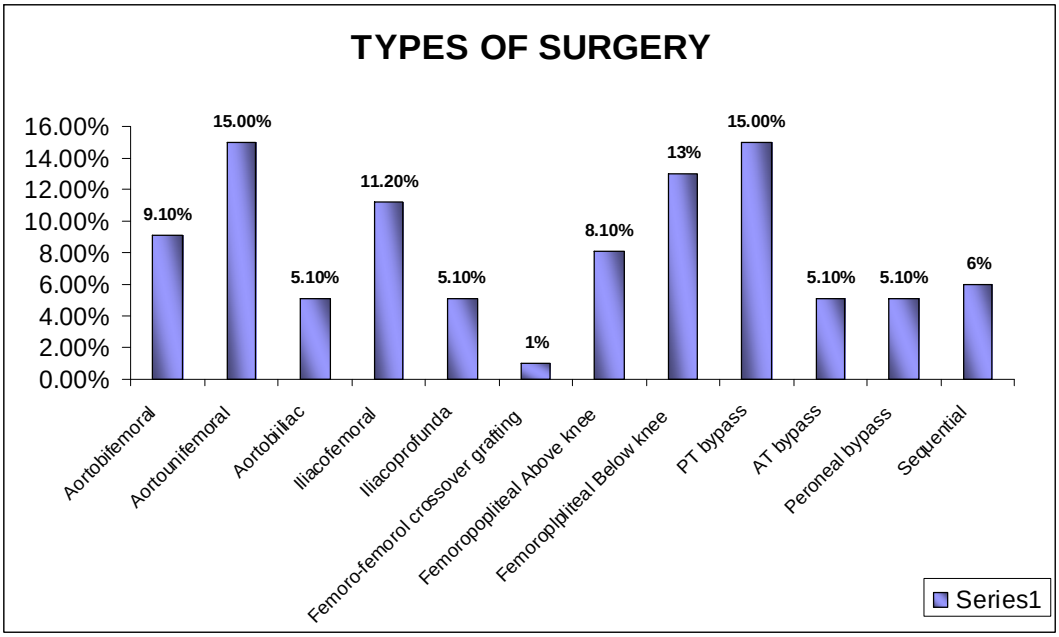
Out of 98 grafts studied, 48 were of prosthetic grafts and 50(including 6 sequential infrainguinal vein bypass) were of autogenous veins used as a conduit for the bypasses. Only two prosthetic grafts were used for infrainguinal above knee femoropopliteal bypass due to lack of vein conduit and all other grafts wee used for proximal aortic and iliac bypasses.

All patients were on life long antiplatelet drugs and or anticoagulation in selected group of patients (e.g., patient with hypercoagulability, grafts at high risk of thrombosis such as single vessel run off and in arteritis patients). Statins were given in all atherosclerotic patients and were continued postoperatively.

Angiograms were done in all failing and thrombosed grafts that required intervention. There findings were well correlated with that of the Duplex scan (100%).

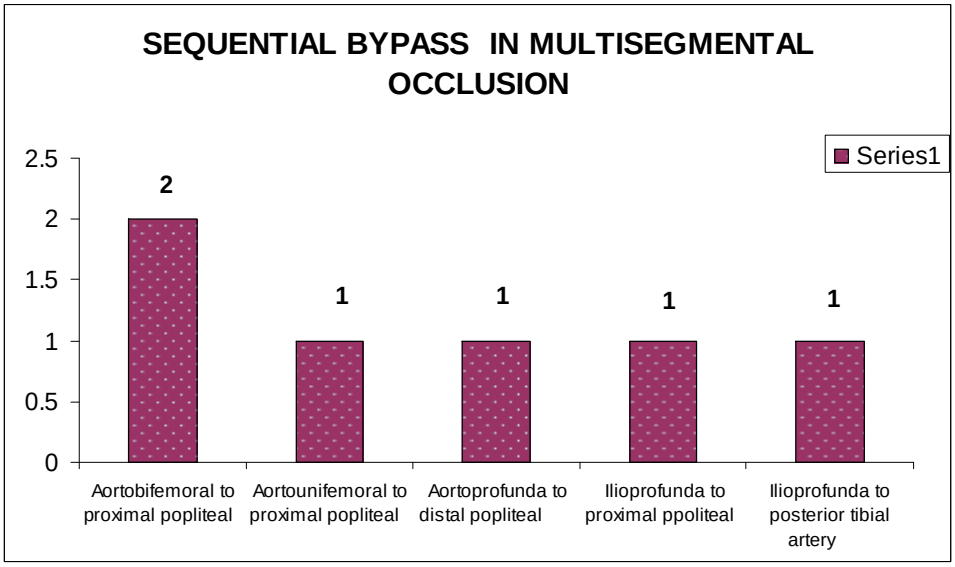
TYPE OF SURGICAL PROCEDURES

Aortobifemoral	-	9 (9.1%)
Aortounifemoral	-	15 (15 %)
Aortobiiliac	-	5 (5.1%)
Iliacofemoral	-	11 (11.2%)
Iliacoprofunda	-	5 (5.1%)
Femoro-femorol crossover grafting	-	1(1%)
Femoropopliteal Above knee	-	8 (8.1%)
Femoroplpliteal Below knee	-	13 (13%)
PT bypass	-	15 (15%)
AT bypass	-	5 (5.1%)
Peroneal bypass	-	5(5.1%)
Sequential	-	6(6%)
Total	-	**98 (grafts)**



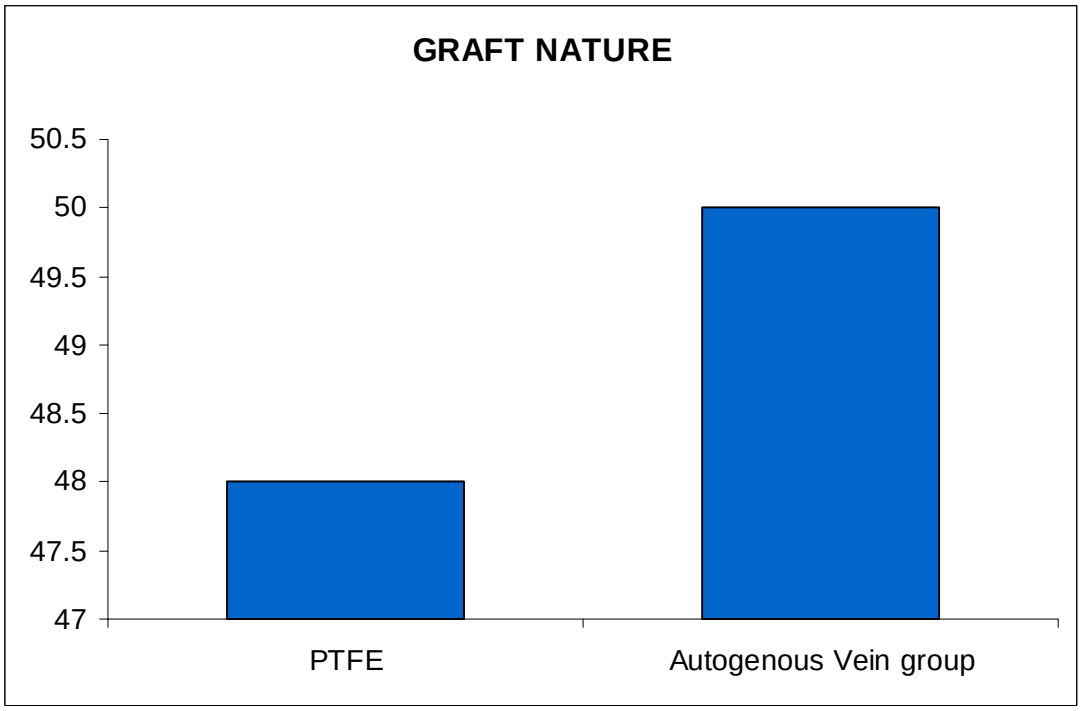
SEQUENTIAL BYPASS IN MULTISEGMENTAL OCCLUSION N=6 (6%)

Aortobifemoral to proximal popliteal	- 2
Aortounifemoral to proximal popliteal	- 1
Aortoprofunda to distal popliteal	- 1
Ilioprofunda to proximal ppoliteal	- 1
Ilioprofunda to posterior tibial artery	- 1
Total	- 6



GRAFT NATURE:

Out of 98 grafts surveyed, autogenous vein were used in 50 bypasses (Infrainguinal – 44 & sequential infraguinal - 6) and prosthetic grafts in 48 patients(Aortic and iliac – 45, Infrainguinal – 2, Fem Fem crossover – 1).

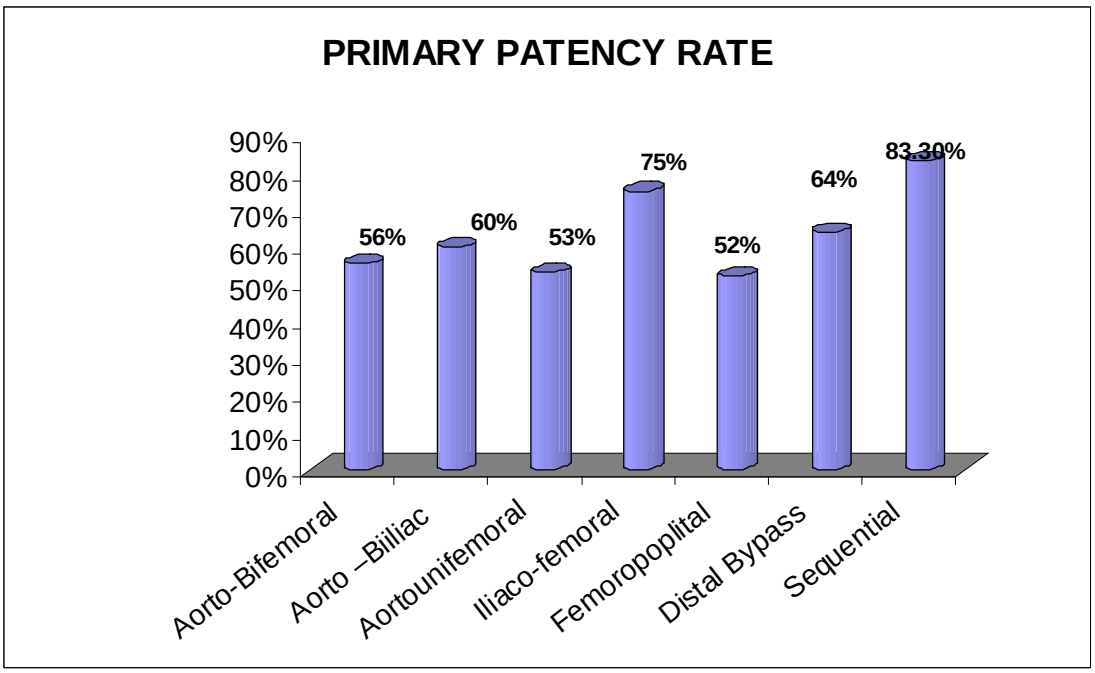


PRIMARY PATENCY RATE AT THE END OF THE STUDY

The primary patency in our study is 61.2 % (n=60 / 98) where Duplex scan showed normal patent graft during the first visit. -

Bypass wise

Aorto-Bifemoral	-	55.5% (5 / 9)
Aorto –Biiliac	-	60% (3 /5)
Aortounifemoral	-	53% (8/15)
Iliaco-femoral	-	75% (12/16)
Femoropoplital	-	52.3% (11/21)
Distal Bypass	-	64% (16/25)
Sequential Bypass	-	83.3% (5 /6)



FAILING GRAFTS ACCORDING TO THE PERIODICITY

Detected during follow up, n = 21 (by duplex scan) and graded as follows

Risk	PTFE Graft (N)	Vein Graft(N)	Number	%
Low	2	1	3	14.2%
Intermediate	2	1	3	14.2%
High	-	5	5	23.8%
Highest	4	6	10	47.6%
Total	8	13	21	

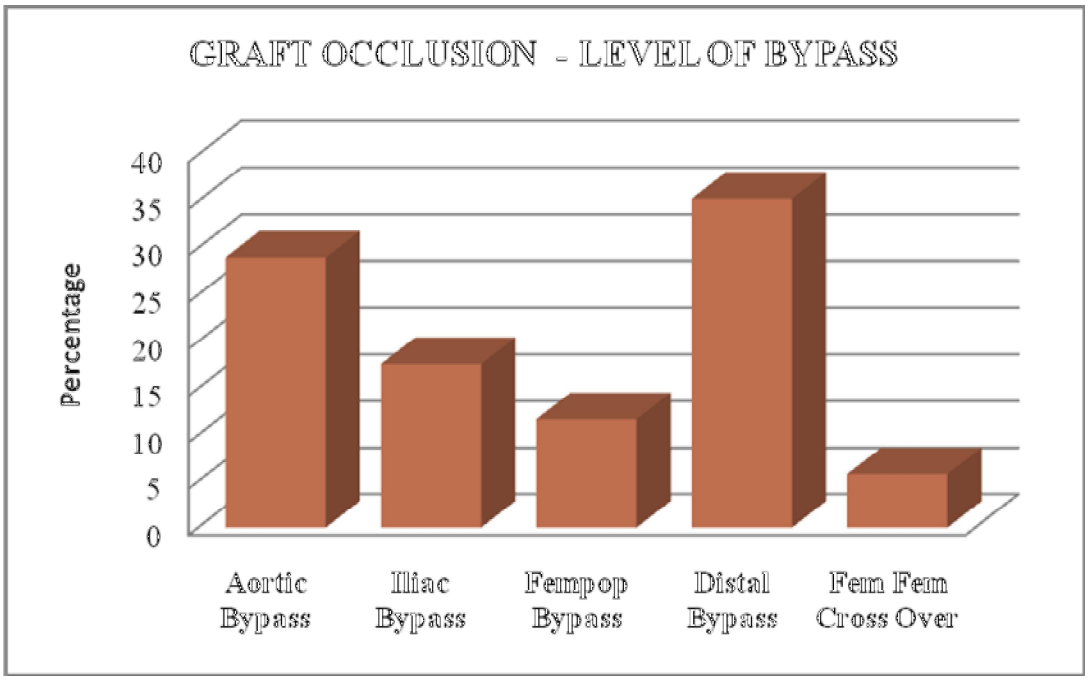
Out of the 21 failing grafts, seven(33.3%) were intervened during the follow up period, out of which only two grafts could be salvaged, two had subsequently occluded following surgery and rest of the three patients expired. Out of the two occluded grafts following revision procedures one required major amputation and one patient was managed conservatively.

So, the overall assisted primary patency rate in this study was increased to 63.26% after salvaging the failing grafts.

Rest of the 14 grafts in the failing group were observed, out of which only one graft was occluded subsequently within three months period.

OCCLUDED GRAFTS IN THE STUDY

In our study, 17 out of 98 grafts(17.3%)were occluded in the follow up period. Revision procedures were performed in all symptomatic patients(n=8) and primary amputation were performed in four patients who had non salvageable foot and rest of the patients were observed. Only three grafts could be salvaged in this group (Aortounifemoral bypass -1, Iliofemoral bypass -1 and Femoropopliteal bypass-1), two required subsequent secondary amputation two were reoccluded and patient expired due to sepsis following graft infection.



INCIDENCE OF GRAFT OCCLUSION AT THE END OF THE STUDY

Total - 17/98 (17.3%)

1. Early thrombosis - 6 (35%)

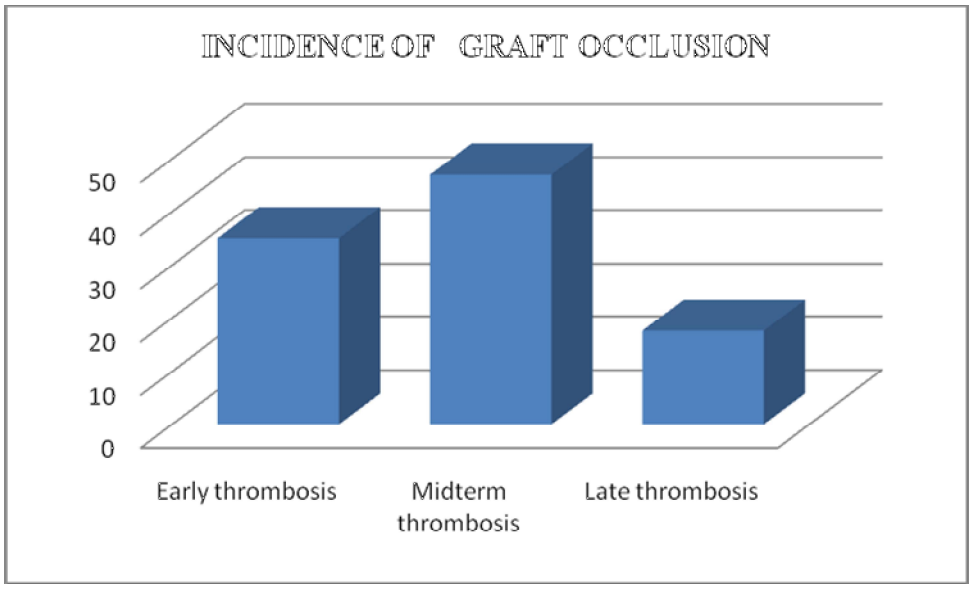
(Iliofemoral – 1, Fempop – 1, PT bypass – 2, AT bypass – 1, Peroneal – 1)

2. Midterm thrombosis - 8 (47%)

(Aortobifemoral – 1, Aortounifemoral – 3, Iliofemoral – 2, Fem- Fem crossover – 1, Peroneal – 1)

3. Late thrombosis - 3 (17.6%)

(AortobiIliac – 1, Femeropopliteal – 1, PT bypass – 1



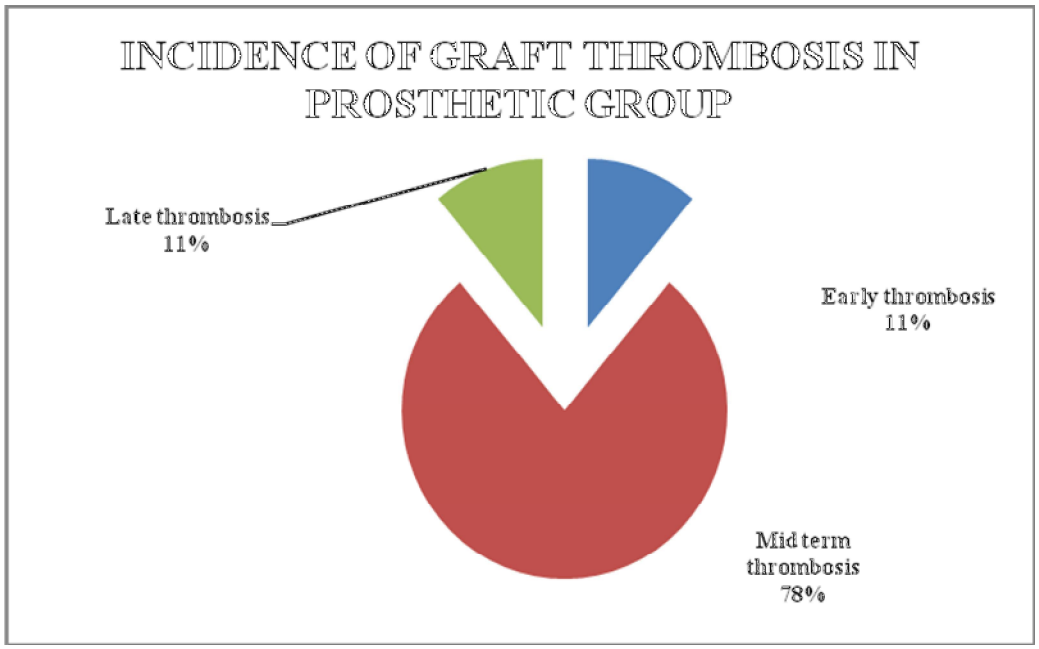
The above table shows the number of grafts occluded during the follow up according the duration. Majority (55%) of the grafts occluded after one month to two years of surgery.

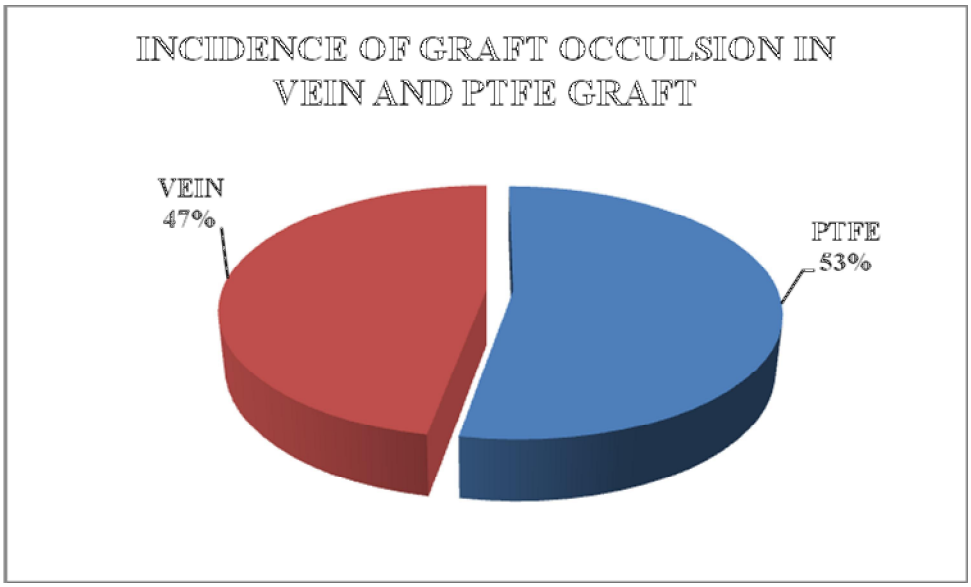
INCIDENCE OF GRAFT THROMBOSIS IN PROSTHETIC GROUP

Early thrombosis - 1

Mid term thrombosis - 7

Late thrombosis - 1



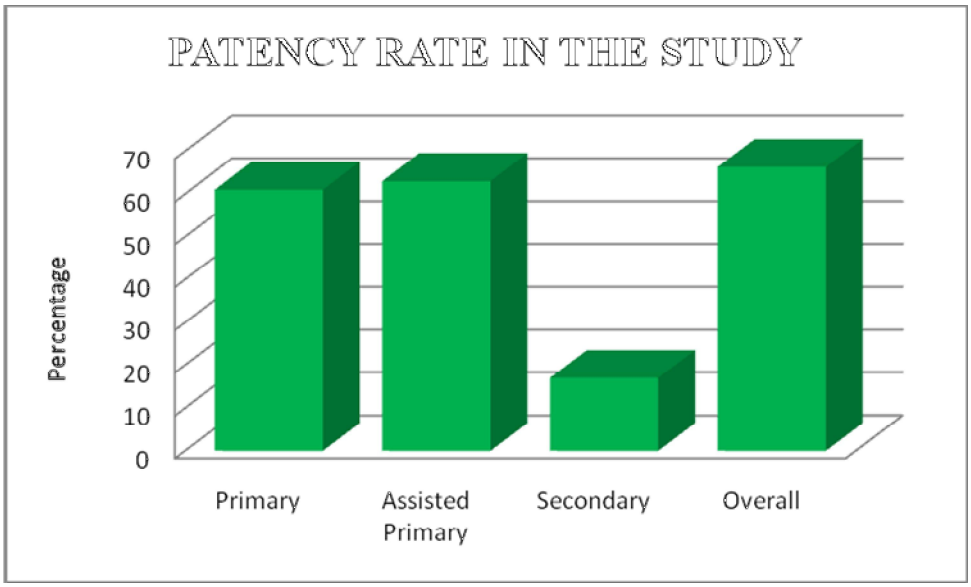


The pie diagram showing the incidence of graft thrombosis is higher in the prosthetic group compared to the vein group (53% Vs 47%)

Majority (70%) of the failing grafts were managed conservatively due to want of availability of endovascular interventions and many of them were asymptomatics with good ABI and they are on close follow up. They will be considered for intervention as and when required.

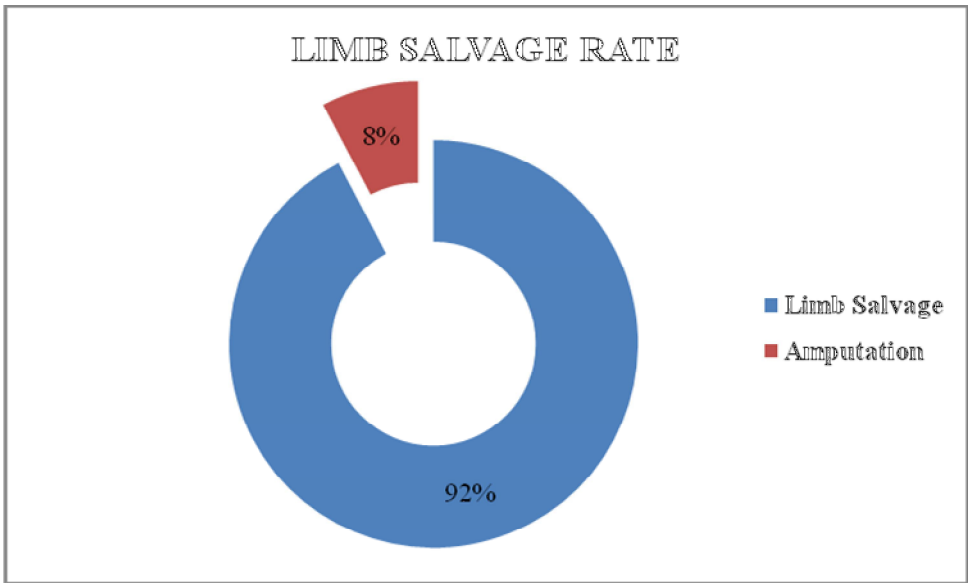
The secondary patency rate in the study was 17.6%(n=3, out of 17 grafts)

And the overall graft patency in the study including assisted primary and secondary were 66.3%.(n=65).



The overall amputation in our study was 7.7% (n=7), out of which six were in the occluded group, one was in the failing group. The mortality rate in this study was 4.3%.

The limb salvage rate in our study was relatively higher (n=92, 92.3%) compared to the graft patency (67.3%) including the patients those were observed.



Rate of graft lesion to that of etiology

	NORMAL	OCCLUSION	FAILING	TOTAL
ASO	42	7	12	61
TAO	15	8	7	30
ARTERITIS	3	2	1	6
HYPERCCOAGULABLE			1	1
TOTAL	60	17	21	98

P=0.185, not significant

TAO and arteritis had increased risk of graft occlusion during the follow up. Only 11% of the grafts were occluded in atherosclerotic patients. This difference is not significant($p = 0.185$)

Rate of graft abnormality with the level of bypass

	NORMAL	OCCLUSION	FAILING
AORTOILIAC	28	8	9
FEMPOP	16	4	7
DISTAL	16	5	5
TOTAL	60	17	21

P=O.96 ,not significant

The occurrence of graft stenosis or occlusion is more common in patients who underwent infrainguinal or infragenicular bypasses. This could be due to the increased resistance and low flow state in peripheral arteries compared to that of central arteries.

Risk factors to that of graft patency

	NORMAL	OCCLUSION	FAILING
SINGLE	24	15	12
DOUBLE	32	2	8
MULTIPLE	4	0	1
TOTAL	60	17	21

P=O.012

The above table shows that there is no statistically significant difference in the influence of risk factors to the graft patency. In our study even patients those who had mulltiple risk factors had primary graft patency of 80%.

Role of anticoagulation in graft patency

POSTOP ORAL ANTICOAGULATION	NORMAL	OCCLUSION	FAILING
YES	15	10	15
NO	45	7	6
TOTAL	60	17	21

P=0.001

The role of anticoagulation in overall graft patency were compared. 77% of patients who did not receive anticoagulation had normal patent graft when compared to only 37% of patients who received anticoagulation had normal graft. This difference is not significant, probably many factors like etiology, level of occlusion, etc., influence the occurrence of graft lesions.

Relationship of Etiology to that of outcome

	LIMB SALVAGE	**AMPUTATION**	**EXPIRED**
ASO	56	2	3
TAO	25	4	1
ARTE	5	1	0
HYPERCOAGULABLE	1	0	0
TOTAL	87	7	4

P=0.62, not significant

Although, majority of the patients were expired in atherosclerosis group compared to that of TAO where the rate of amputation was high, this difference is not statistically significant.

Influence of risk factors to the outcome

	LIMB SALVAGE	AMPUTATION	EXPIRED
Single	44	6	1
Double	38	1	3
Multiple	5	0	0
TOTAL	87	7	4

P=0.08

As the number of risk factors increases the rate of mortality increases . This value is not statistically significant because those who had three or multiple risk factors did not have any mortality in our study. And at the same time there is no difference in the influence of risk factors on graft patency.

Relationship of the graft nature to the patency

	NORMAL	OCCLUSION	FAILING
PTFE	29	9	10
VEIN	31	8	11
TOTAL	60	17	21

P=0.93, not significant.

In our study the rate of graft stenosis is more common in venous group compared to that prosthetic group where occlusion is more common. This is not statistically significant.

Relationship of the type of surgery to the outcome

	LIMB SALVAGE	AMPUTATION	EXPIRED
AORTOILIAC	41	1	3
FEMPOP	22	4	1
DISTAL BYPASS	24	2	0
TOTAL	87	7	4

P=0.21 Although this data is not statistically significant, aortic surgeries had higher mortality when compared to infrainguinal surgeries. The rate of amputation was more in infrainguinal bypass group(P=0.21)

DISCUSSION

Despite advances in surgical techniques peripheral arterial bypass graft failure occurs and remains a major problem for vascular surgeon and rescue of thrombosed graft especially vein graft with thrombectomy or thrombolysis usually do not result in restoration of durable patency. Furthermore replacement of a failed bypass graft with a new bypass graft poses a variety of challenge to the surgeon, including scarring, shortage of autogenous vein and increased patient morbidity.Thus the result of repeat bypass surgery after failed bypass are inferior to those of primary bypass surgery. It is therefore imperative to maintain the patency of peripheral bypass grafts.

As arterial bypass surgeries are palliative procedures perse not curing, the disease progression, highlighting the need for graft surveillance. Although clinical examination, ankle brachial index during the postoperative period help in detecting the hemodynamically significant lesion, color Doppler has shown a major difference in detecting the early failing grafts even in asymptomatic patients.

From May 2007 to April 2009 review of a prospectively collected data was performed of 98 grafts in 92 patients who underwent bypass for lower limb ischemia due to various etiology, was randomly selected and enrolled in this study. The surgeries were performed by different surgeons in our department.

In our study, duplex scan had 100% sensitivity in detecting the graft lesion as compared to that of the study done by Calligaro (Reference : Practical Vascular

Surgery, James S.T.) and colleagues where they had shown only 81% sensitivity when compared with clinical examination and ABI.

According to Louis (Literature - From the Society of Vascular Surgery, June 2004), study the incidence of mid term graft failure was 20 to 50% which is comparable to our study where the mid term failure was upto 55% for infrainguinal vein bypass.

Wolfe et al (Vascular and Endovascular Intervention and Surgery update 1996, Dr. Pinjala Ramakrishna, M.S. FRCS) showed that 50 to 80% of lesions may be missed if we depend on ABI, in our study also the reliability of ABI in identifying the failing graft was about 58 % which is inferior to that of duplex scan comparable with that of Calligro et al study.

The positive predictive value for Duplex scan in defining normal patent graft is 100%. Even though duplex identifies critical lesion in vein grafts, almost all of them resulted in thrombosis at the time of intervention and all of them needed a new conduit.

The incidence of failing graft in infrainguinal bypass is more for PTFE group (50%) than vein group which is of 18 % when compared to other studies by Michael Belkin etal where they reported failure rate of 28.6% when compared to vein groups of 13.6% failure rate. (Journal of Vascular Surgery, February 1995)

Even though our study is of two year period, the primary graft patency was better in atherosclerosis(70%) than that of TAO(25%) and arteritis(5%). The rate of primary patency in TAO was 49% in a study BY Sasajima and colleagues (Manual of vascular disease by Sanjay Rajagopalan MD, Edition-2005)

In this study, the infection rate in prosthetics graft was 2 % comparable to the graft infection of Aortofemoral bypass 1 % study by Moore WS, cole CW(Infection in prosthetic vascular grafts, A comprehensive review 1991)

The incidence of Anastomotic femoral aneurysm is 2.1 % (Anastomotic aneurysm incidence2.4 % in femoral arteries in literature Goldstone J .-complications in vascular surgery 1991) The factors precipitating pseudoaneurysm are suture failure,graft infection,graft dilatation ,End-Side anastomosis and arterial degeneration.

In our study we have observed that diabetic mellitus does not adversely affect graft patency and in one patient, who is a diabetic underwent Aortouni-iliac bypass using PTFE graft showed 8 years of primary patency rate on angioevaluation for peripheral arterial occlusive disease in opposite leg. (Stated in journals -Diabetes does not adversely affect the patency rate of a graft **in** chapter**, Influence of diabetes & other factors on graft patency (journal of vas surgery august 2007**).

The overall patency rate for Aortic bypass in this study is 65.5% when compared to other series (Aorto femoral bypass Patency 85 – 90 % - Brewster DC,Cooke JC –Long term results in vascular surgery -1993) which can be explained ,by the lesser diameter of arteries when compared to western population and the

combination of early inflammatory arteritis and subsequent atherosclerotic pathology in the evolution of peripheral arterial occlusion.

The overall patency rate for Femoropopliteal bypass using vein in this study is 52.3% when compared to other series (Patency rate for Femeropopliteal bypass with vein is 84 % both for proximal and distal bypass- Review by Dalman - 2000) which can be explained by the etiological factors (20% of the patients were of TAO and Arteritis n=4 who had elevated CRP and where we were forced to do bypass under steroid cover due immediate threat to limb) and since our institution is a teaching center , the residents tend to get more chances of doing bypasses and hence in the learning period technical problems are more.

The primary patency rate for PTFE Above knee Femoropopliteal bypass in this study is 50% (compared to 79 % in the western series – Review by Dalman - 2000)This can be explained due to low sample in this study since, we mostly prefer Autogenous vein for all infrainguinal Bypass.

The overall patency rate for distal bypass in this study is 64% (n=16) when compared to 77 % reported in literature (Review of results in infrainguinal bypass Dalman - 2000)

Most of the vein graft failed due to intrinsic graft lesion n=9 (54%) which is comparable with study done by **Donaldson, Mills coworkers Rutherford** (60 % of vein graft failed due to focal intrinsic lesion)

In this study 18 % of vein group failed at the end of this study when compared to 15-20 % in study by **Donaldson, Mills coworker**)

In this study 83 % of vein group developed lesion and thrombosed by one year when compared to (**Mills** description 80 % lesion in 1 year)

In this study we used a PTFE – Vein composite graft (n=2) in Redo surgery for infrapopliteal bypass n=1 and distal bypass n=1 .The outcome are early graft thrombosis 100% and amputation rate is 50% when compared to literature which showed 49.4 % Graft thrombosis and 40% amputation rate- **P.A.STONEBRIDGE etal British journal of surgery February 2000)**

Distal bypass using PTFE and a distal anastomotic interposition vein cuff is to avoid compliance mismatch between the prosthetic graft and native artery.The protective effect may be humoral in origin ,possibly by reducing the activation of growth factors by the presence of an autogenous endothelium buffer zone. **(P.A.STONEBRIDGE etal British journal of surgery February 2000)**

The rate of limb salvage in patients with failed grafts was 65% when compared to literature (only 50% at 2 yrs after failure. **- Midwestern vascular surgical society Chicago September 2003)**

In our study 20 %(n=1) of revised grafts developed subsequent distal graft critical stenosis (Arteritis with elevated CRP due to steroid default) and additional revisional procedure in the form of PTFE patch plasty and graft salvaged . This

reflects the ongoing disease activity the cause for recurrent graft failure which needs. Vigilant ongoing surveillance , for revised grafts because 30.9% of revised grafts will develop additional lesions that will, require repair as reported in literature**.(Society of vascular surgery. Anaheim, California,J une 2004)**

In our study PTFE grafts to Femoropopliteal bypass also benefited from surveillance by identification of anastomotic stenosis n=1/2(50%) in contradictory to report in literature - KEITH D .CALLIGARO Annals of vas surgery –Aug 2001- Results support the graft surveillance protocol for femorotibial but not femoropopliteal ,prosthetic grafts

In our study duplex report correlated 100 % with report of CT angiogram and conventional angiogram similar to other study CT Angiogram-Comparison with duplex and DSA(Jurgen K Willmann,MD etall Institution of diagnostic radiology and cardio vascular surgery ,Zurich, Switzerland Sep 2002 -No statistical difference in sensitivity or specificity between CTA and duplex in detection of graft lesion)

We start patients on long term oral anticoagulants who were asymptomatic with duplex report of Low flow graft to prevent graft occlusion.the benefits have been studied by R. Brumberg etal reporting 89% patency in patients on warfarin for low flow graft when compared to 55% who were subtherapeutic or not anticoagulated.(Annals of Vascular surgery 2007- Therapeutic warfarin augment the patency of low flow graft)

In our study we have observed less graft lesion in infrainguinal bypass vein graft who were on statins (ASO groups 47% n=9) than when compared to patients not on statin (TAO and Arteritis groups 53% n=10) as reported in literature .

Statin therapy is associated with improved patency in infrainguinal vein graft by preventing stenosis and occlusion . (Thomas a abbruzzese New England Society for vascular Surgery 2004 -HMGA CO A reductase inhibitor(3-hydroxy 3-methyl coenzymeA inhibitors) because of Atheroprotective , Antithrombotic & Antiinflammatory (independent effect) apart from lipid lowering effect. Control group 2 years Revised graft patency rate 83% and Statin group 94 % .Secondary patency rate in control group 92% and Statin group 97 %)

CONCLUSION

- Graft surveillance programme should be mandatory in all peripheral arterial bypass grafts. Limb salvage rate may be increased by doing intraoperative duplex scan which detects the failing grafts in the operation theatre itself, thereby avoiding the need for second anaesthesia and surgery.

- The usefulness of duplex scan in improving the assisted primary patency which has been proved by many studies mandates the need for graft surveillance.

- In view of its non invasiveness, Duplex scan plays a major role in detecting the hemodynamically failing grafts before the patient becomes symptomatic. The sensitivity and specificity of it is comparable with that of the invasive angiogram, hence avoiding the need for it.

- The dependability of Ankle brachial index increases when it is coupled with clinical examination and color Doppler ultrasound than independently.

- One should be aggressive in salvaging the autogenous vein grafts as the intraluminal thrombus fixed to the intimal layer disrupts the endothelial function whereas thrombosis of prosthetic grafts is not as detrimental as vein occlusion which may be removed by thrombolysis or thrombectomy.

- Though the presence of risk factors increases the cardiovascular mortality in these patients during the perioperative period, it does not affect the overall graft patency.

- In occluded grafts, even though revision procedures are time consuming than simple thrombectomy one should not hesitant to do it to improve the secondary patency.

- No single approach is appropriate for all patients and thus the interventions must be tailored to the individual.

- Long term anticoagulation with INR monitoring should be considered for selected group of patients with high risk of graft thrombosis or in those who required revision procedures.

- Vigilant graft surveillance is essential throughout the life to identify the late lesion and also the future lesion in revised grafts.

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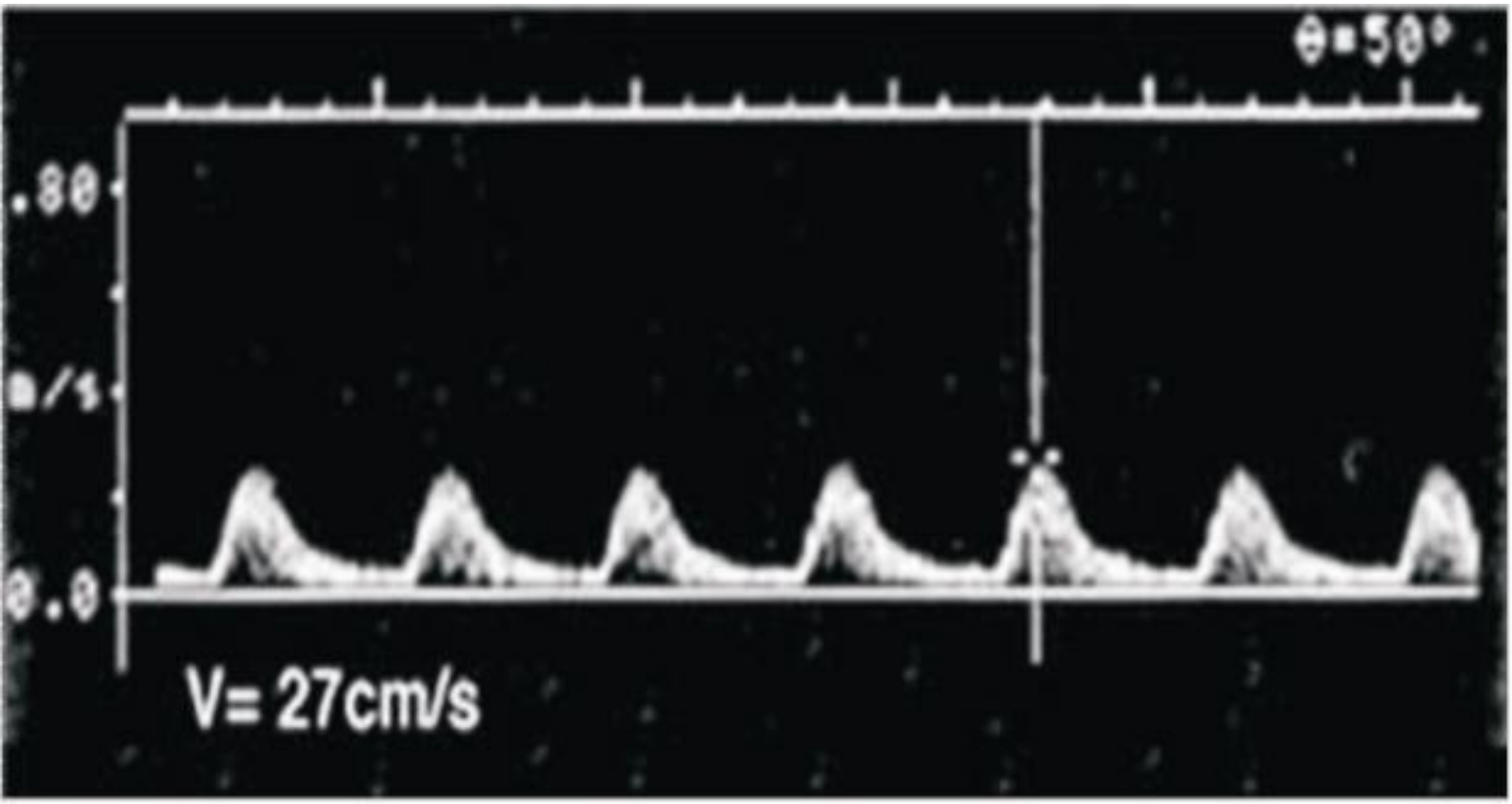
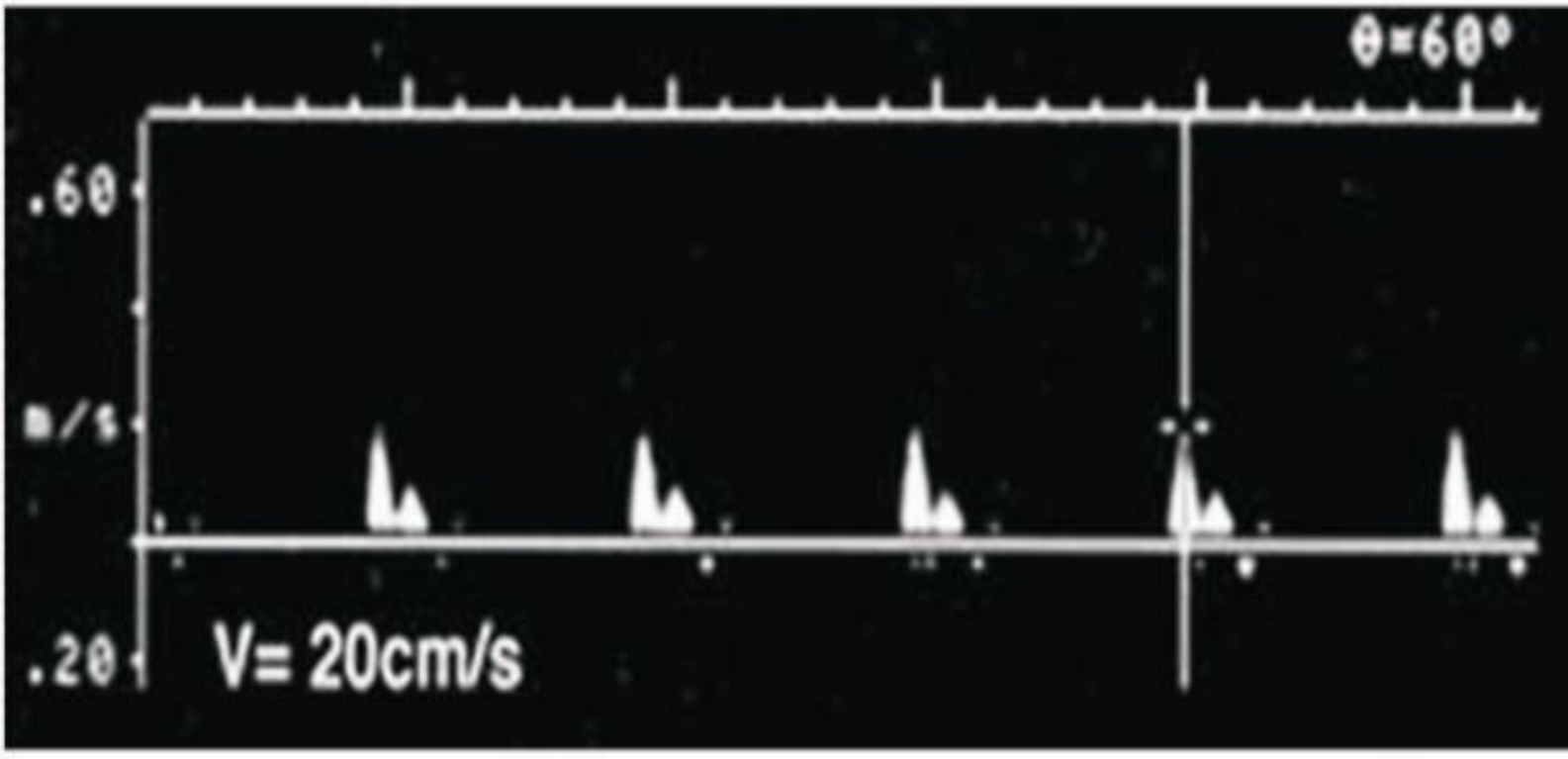
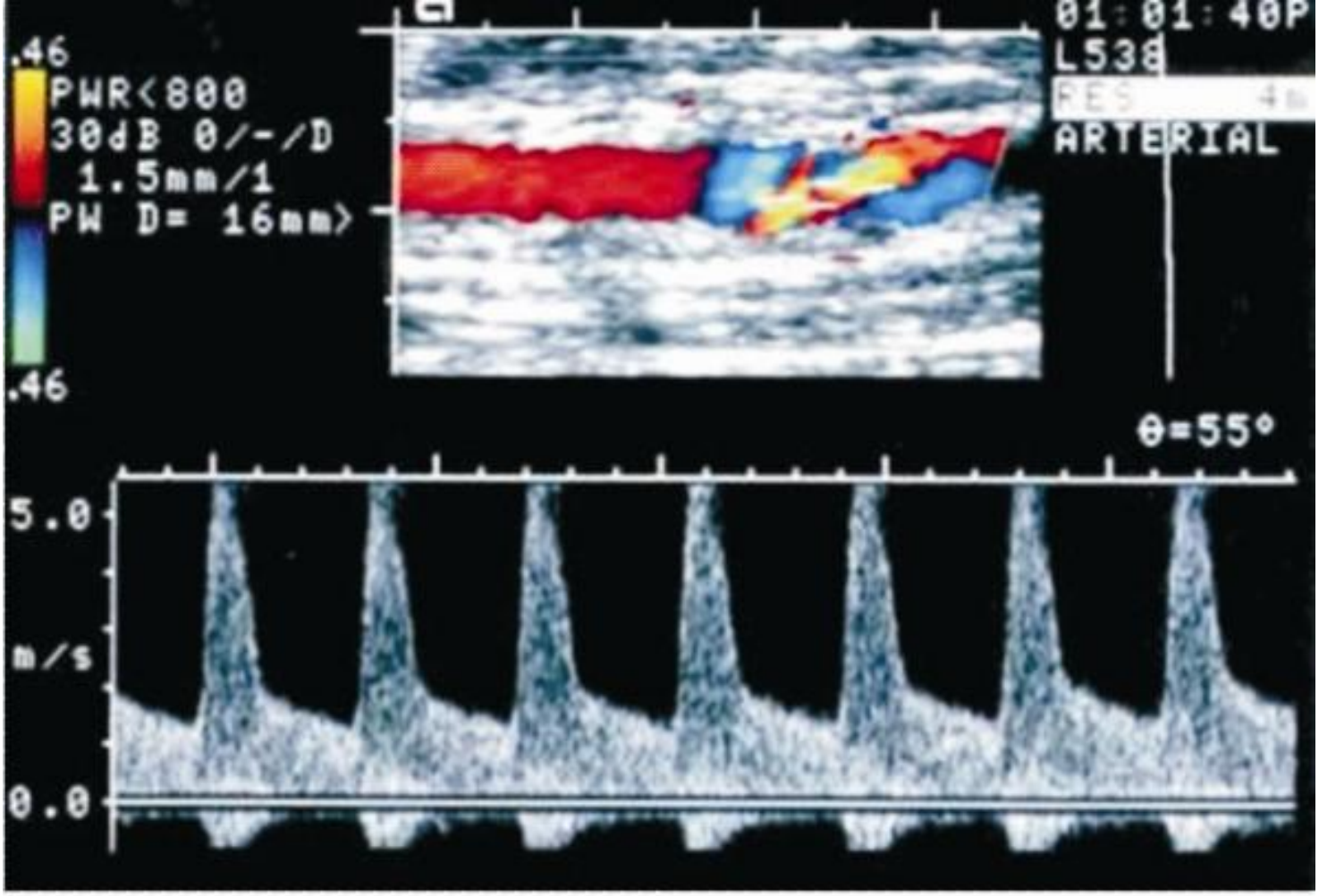


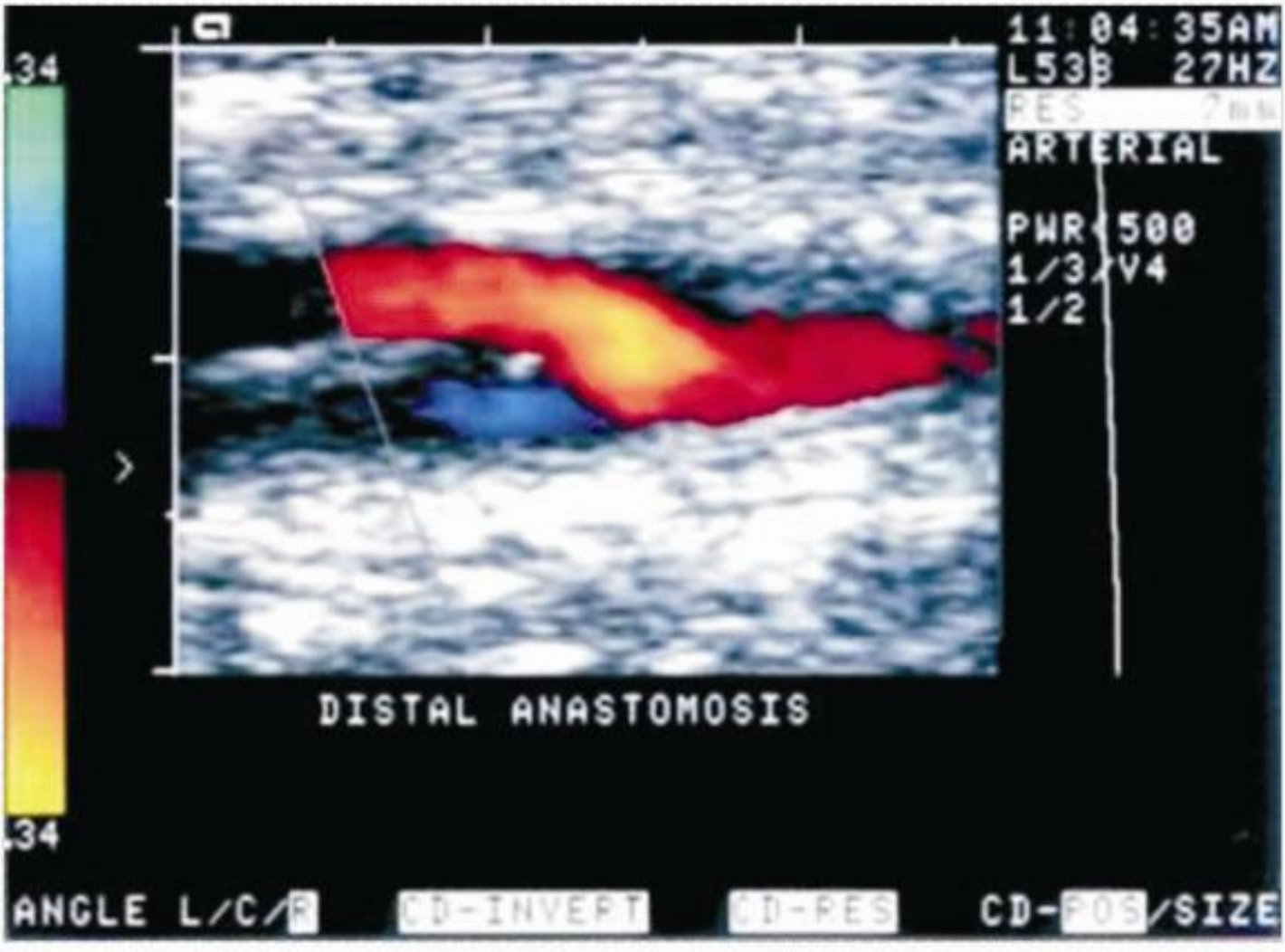
Low flow low resistance waveform –inflow or proximal stenosis



High resistance low flow staccato waveform impending failure –distal high grade stenosis



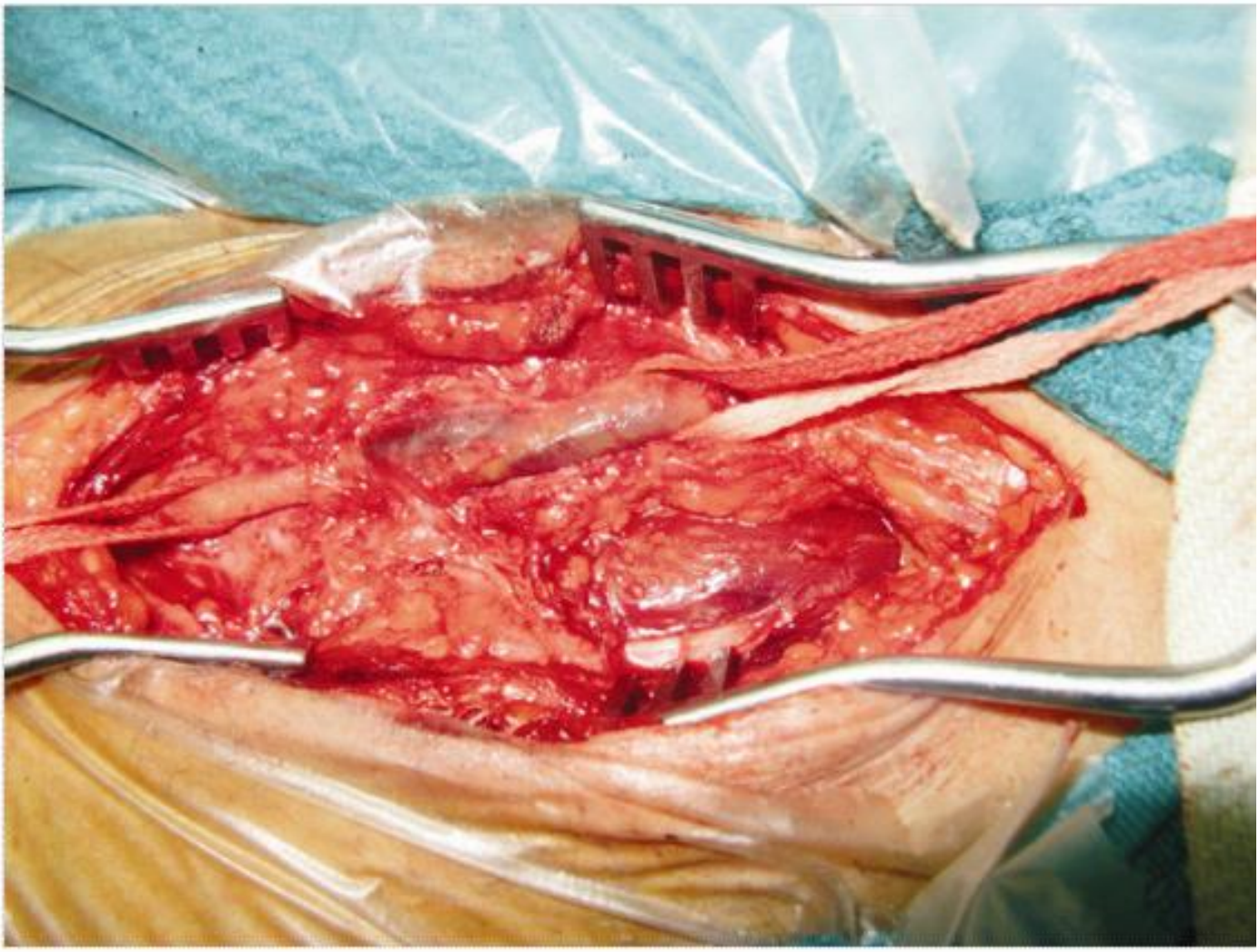
Graft body stenosis disturbed color flow pattern



Normal graft CD image of distal anastomosis

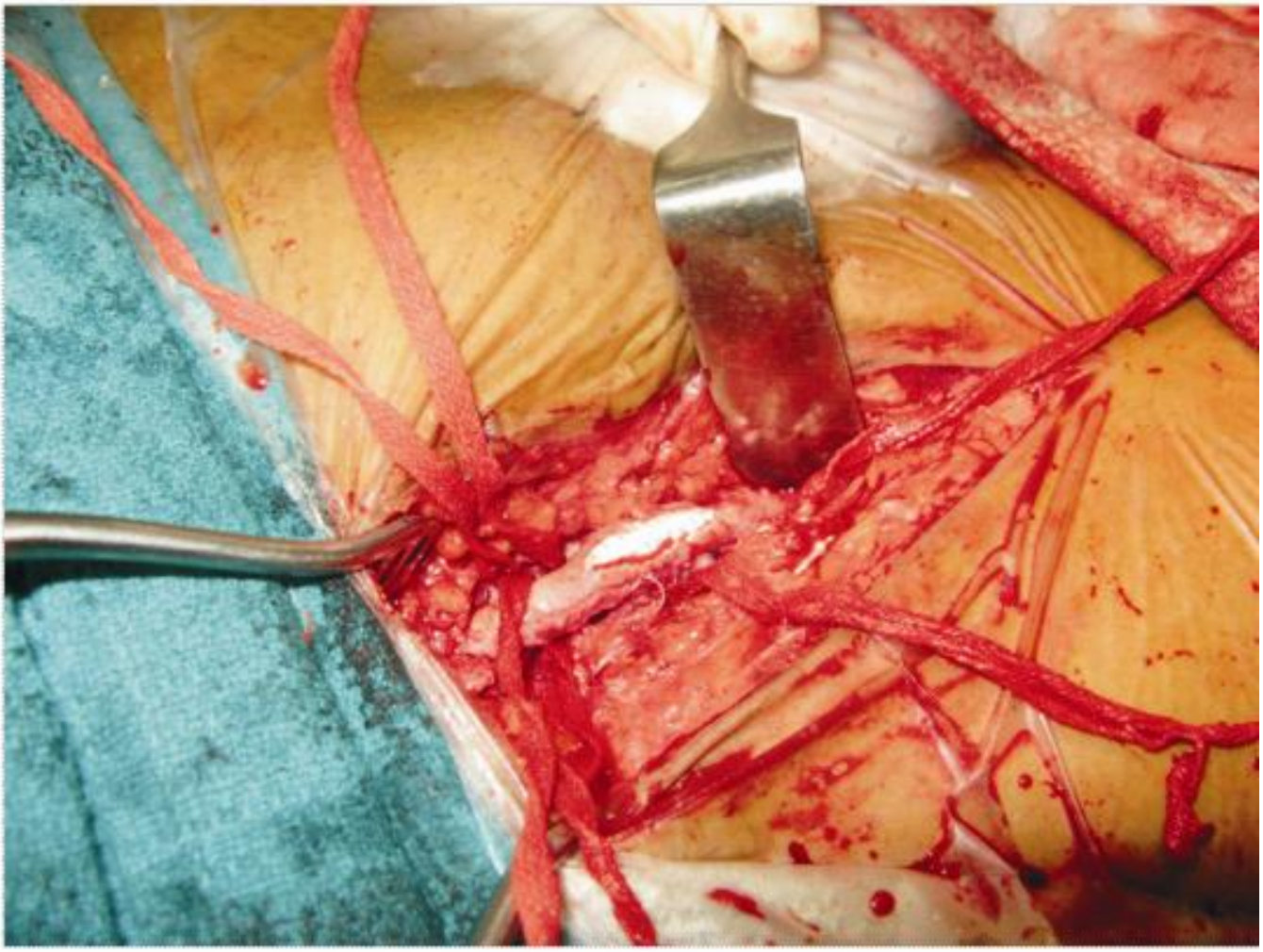
Aorto bifemoral bypass

- Left limb graft occlusion

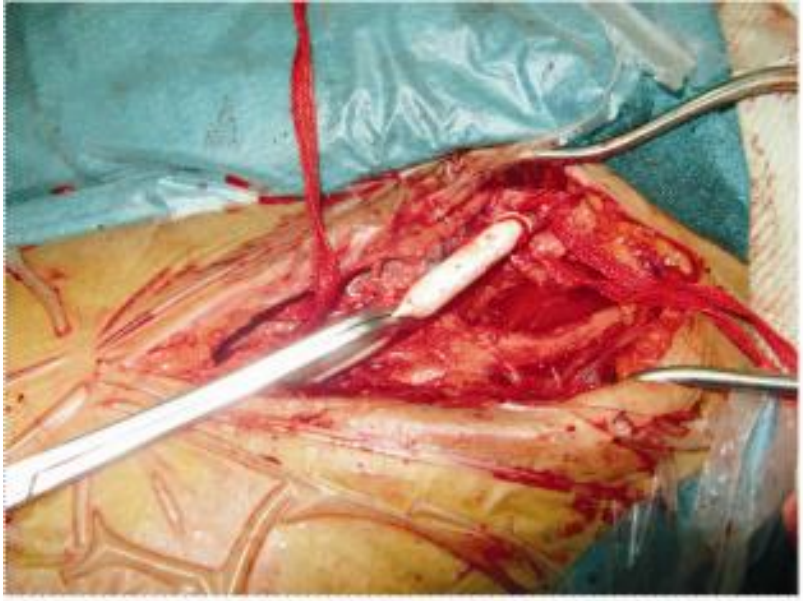


PTFE Graft thrombosis

Graft thrombectomy using - Adherent clot catheter

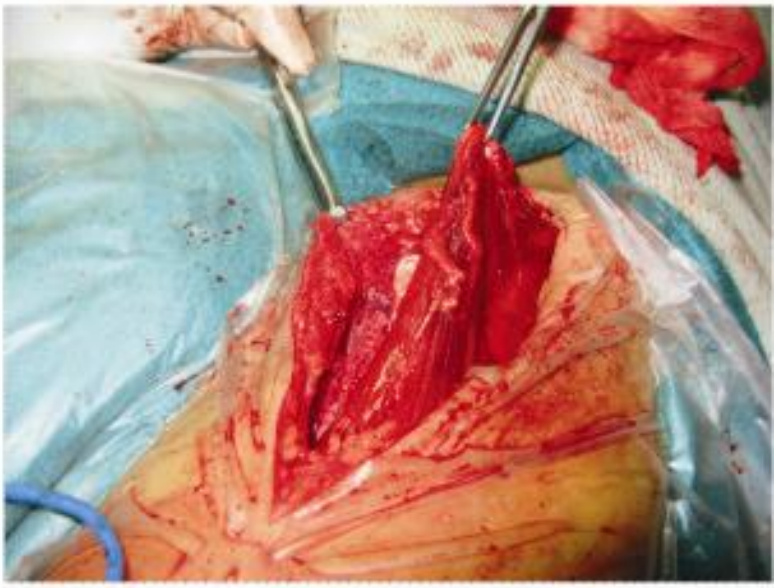


PTFE patch plasty of distal anastomosis



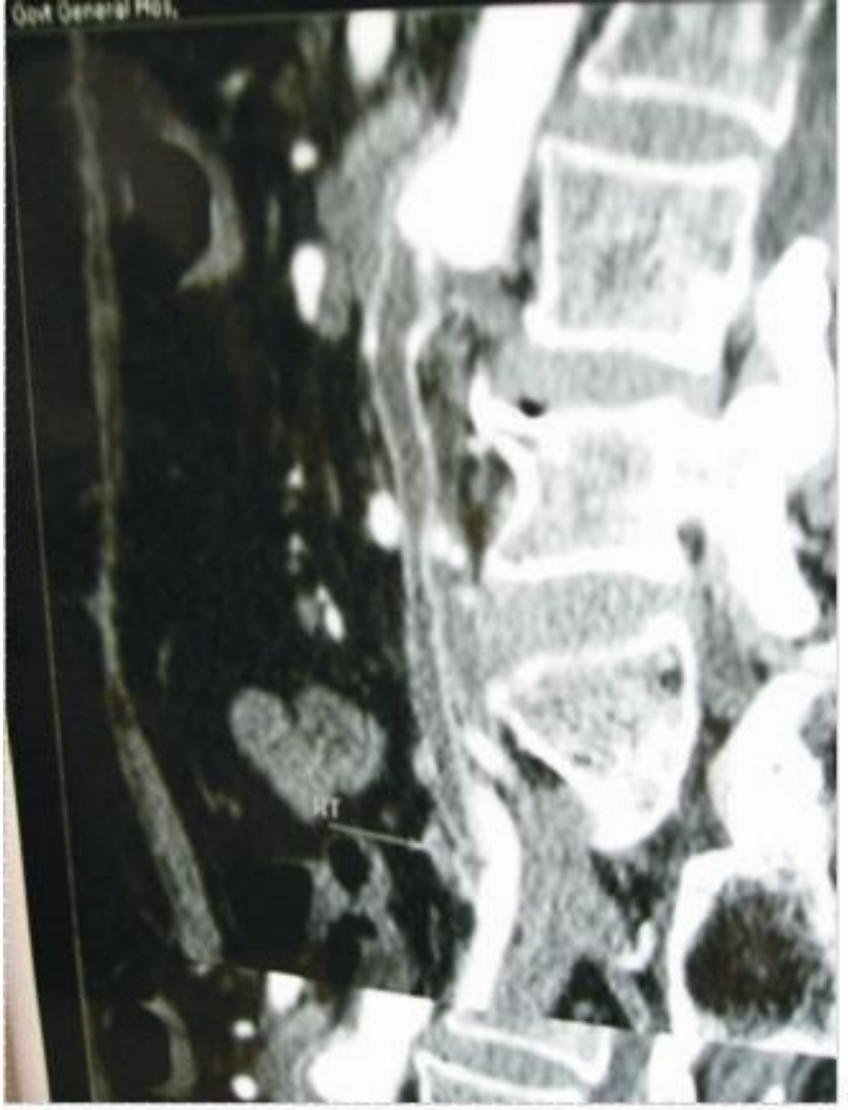
Distal Graft extension

Sartorius Muscle cover



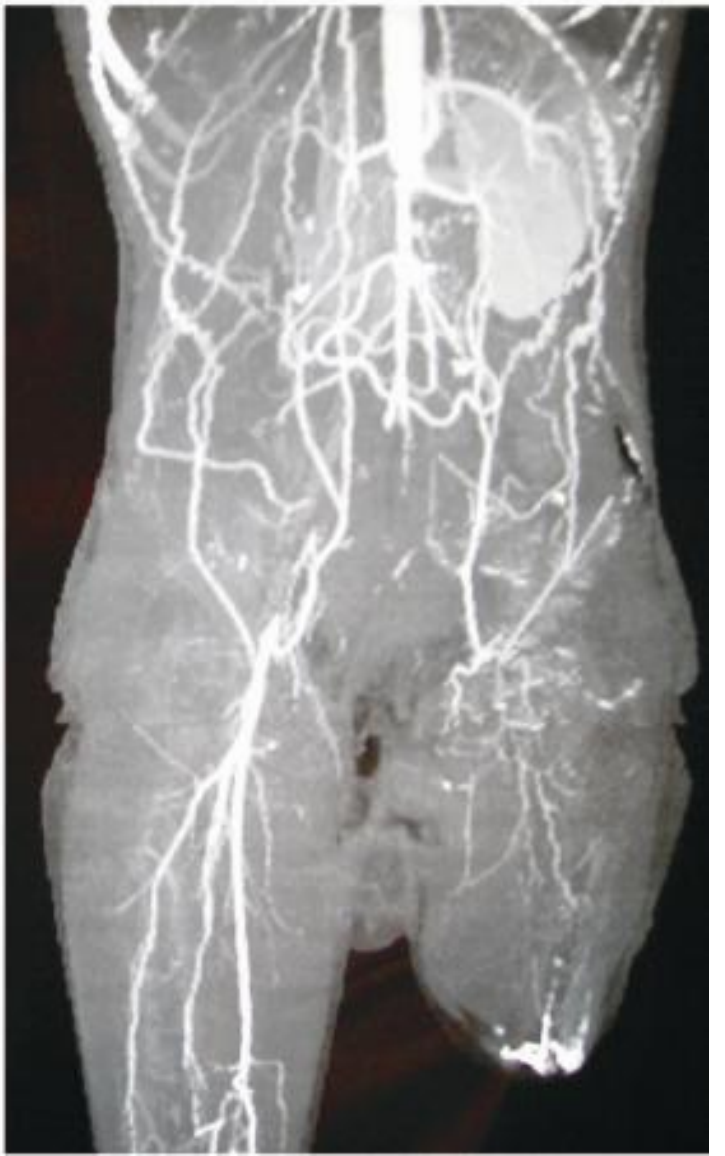
Completion Angiogram

after revision procedure

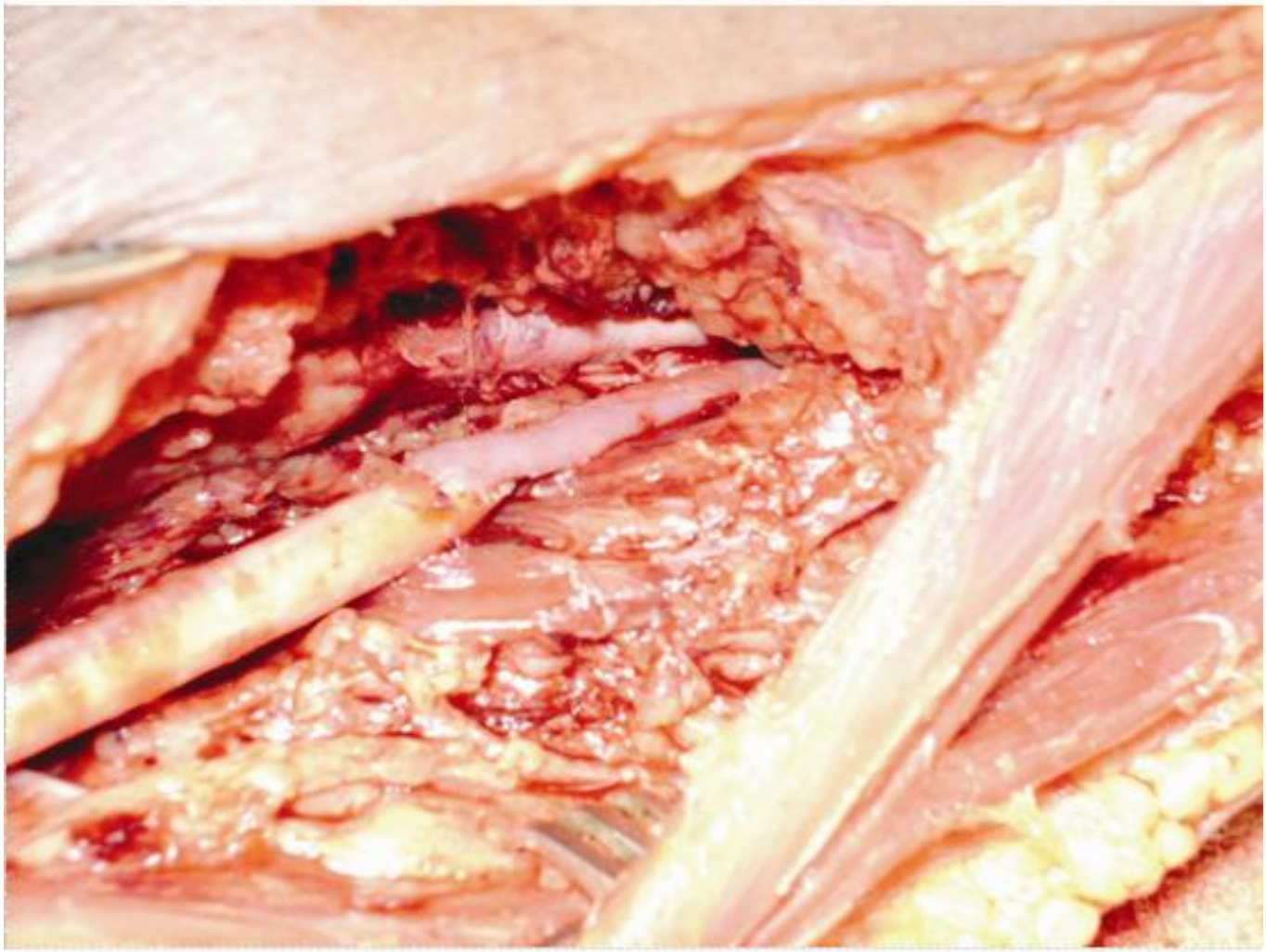


Aorto bi-iliac bypass graft occlusion

Aorto right unifemoral bypass graft occlusion old left AK amputee hypercoagulable state



Right popliteal to Distal PT bypass (CT angio Patent graft)



Left femoro to distal popliteal composite graft bypass